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Major Article

Health care worker hand contamination at critical moments in outpatient care settings

James Bingham MS [a,*], Ginnie Abell BA, RN, CIC [b], LeAnne Kienast BS [a], Lorie Lerner MSN, MDiv, RN, CNS [c], Brittney Matuschek BS [a], Wanda Mullins MPH, BSN, RN, CIC [d], Albert Parker PhD [e], Nancy Reynolds BSN, RN, CIC [b], Diane Salisbury MSN, RN, CIC [f], Joan Seidel MA, BSN, RN, CIC [g], Elizabeth Young BSN, RN, CIC [h], Jane Kirk MSN, RN, CIC [a]

[a] *GOJO Industries, Inc, Akron, OH*
[b] *Summa Health System, Akron, OH*
[c] *LJL Consulting, Akron, OH*
[d] *Cleveland Clinic Akron General, Akron, OH*
[e] *Center for Biofilm Engineering, Department of Mathematical Sciences, Montana State University, Bozeman, MT*
[f] *Salisbury IP Consulting, LLC, Akron, OH*
[g] *University Hospitals Portage Medical Center, Ravenna, OH*
[h] *Infection Prevention Consultant, Vermilion, OH*

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Background: The delivery of health care in outpatient settings has steadily increased over the past 40 years. The risk of infection in these settings is considered to be low. However, the increasing severity of illness and complexity of care in outpatient settings creates a need to reexamine the transmission of pathogens in this setting.

Materials and Methods: Seventeen health care workers from 4 wound care facilities were sampled during 46 patient care encounters to determine the presence of health care-associated pathogens (ie, methicillin-resistant *Staphylococcus aureus*, vancomycin-resistant *Enterococcus*, multidrug-resistant *Acinetobacter* species, and *Clostridium difficile*) on their hands at key moments of care.

Results: Health care workers acquired at least 1 pathogen on their hands during 28.3% of all patient care encounters. Hands sampled before a clean or aseptic procedure and hands sampled after body fluid exposure risk were each contaminated in 17.4% of instances. Hand contamination occurred in 19.6% of instances where health care workers wore gloves during care compared with 14.6% when health care workers were ungloved.

Conclusions: Contamination of health care workers' hands presents a significant risk of pathogen transmission in outpatient settings. Gloving education, hand hygiene solutions at the point of care, and hand hygiene surveillance are important solutions for reducing transmission of pathogenic organisms.

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BACKGROUND

The delivery of health care has transitioned from centralized, acute care hospitals to community-based outpatient (ambulatory) care settings over the past several decades. Outpatient care settings consist of physician offices, hospital emergency departments, hospital and nonhospital-based clinics, surgical centers, and many other specialized service centers.[1,2] During the 10-year period from 1997-2007, outpatient care visits increased by 25% to an estimated 1.2 billion visits with a rate of 4 visits per year per person.[3] The rise in utilization of outpatient care centers has been attributed to advancement in medical technology, insurance reimbursement, convenience of care, and efforts to control health care costs.

Infection prevention infrastructure and resources in outpatient settings are often not equivalent to those of acute care hospitals.[4,5] The lack of infection prevention resources combined with the

* Address correspondence to James Bingham, MS, GOJO Industries, Inc, PO Box 991, Akron, OH 44309.
E-mail address: binghamj@gojo.com (J. Bingham).
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increasing severity of illness, increasingly complicated procedures, and time pressure make infection prevention programs and practices critical to protect patients and health care workers (HCWs) from health care-associated infections (HAIs) in outpatient settings. In 2014, the Centers for Disease Control and Prevention (CDC) updated the guide to infection prevention in outpatient settings to highlight the need for dedicated infection prevention staff, training, HAI surveillance, and the use of standard precautions.[1] In addition, the World Health Organization (WHO) adapted their recommendations on hand hygiene best practices for outpatient settings.[2]

Hand hygiene is among the most important measures to prevent the transmission and acquisition of HAIs.[6] The WHO has defined 5 key moments for hand hygiene in outpatient care settings and CDC has suggested 6 key situations when hand hygiene should be performed.[6,7] Despite the hand hygiene recommendations, the scientific evidence of microbial transmission during critical moments of care in outpatient care settings is limited.[2] In this study, the primary research objective was to quantify the presence of health care-associated pathogens on the hands of HCWs at 2 of the key moments for hand hygiene in an outpatient care setting and to determine the influence of glove use. In addition, the study sought to clarify the distribution of hand contamination among HCWs in outpatient care facilities.

MATERIALS AND METHODS

Study design

The institutional review board at each facility approved the study. HCWs at 4 wound care facilities in northeastern Ohio were invited to participate on each day of sampling and those who chose to participate signed an informed consent. Sampling took place on 2 separate days at each facility. Participants were asked to perform routine patient care activities, including hand hygiene, with no deviation from their routine practices, except requiring hand hygiene before entering the examination room. Research staff monitored and recorded the application of hand hygiene before entering the examination room. For this study, a patient care encounter was defined as the entire care process for 1 patient, including patient rooming, initial patient contact, wound care, and patient discharge. During the patient care encounter hand samples were taken before performing a clean or aseptic procedure (WHO moment 2) and after gloves were removed following body fluid exposure risk (WHO moment 3). In this study moment 2 corresponded to the moment immediately before wound treatment and moment 3 corresponded to the moment immediately after wound treatment (Fig 1). WHO moments 2 and 3 relate to the moments in the Canadian guidelines 4 moments and are similar to the indications for hand hygiene recommended in the CDC guidelines. Only paired samples taken before moment 2 and after moment 3 from the same patient were included in the results. Participants were allowed to be sampled while giving care to a maximum of 3 patients (ie, 6 total samples) per day to limit workflow disruption. Samples were only taken from HCWs who were providing care during the entire patient encounter of a single patient (ie, rooming to exam conclusion). When multiple patient encounters were sampled from the same HCW during the same clinic day, the encounters sampled were always taken sequentially and never occurred simultaneously. Observation of hand hygiene upon room entry and self-reported glove use were recorded during patient care. Three of the facilities followed CDC hand hygiene guidelines, whereas 1 facility followed the WHO guidelines.

Hand sampling

A hand sampling method described in the American Society for Testing and Materials Standard Test Method E1115-10 was used to recover bacteria from HCWs' hands. Briefly, a sterile, powder-free surgical glove was placed on the dominant hand of the participant, and 50 mL sterile sampling solution (0.075 mol/L phosphate buffer, pH 7.9, containing 0.1% polysorbate 80, 0.1% sodium thiosulfate, and 0.3% lecithin) was added to the glove. The glove was secured at the wrist with a tourniquet, and the gloved hand was uniformly massaged for 1 minute by the research staff. While the glove remained on the hand, 20 mL sampling solution was aseptically removed from the glove and placed in a sterile sample cup. After sampling, the participants washed hands to remove any residual sampling solution.

Bacteria recovery and identification

The sampled solution was centrifuged at 10,000 g for 10 minutes, and 15 mL supernatant was discarded. The pellet was resuspended in the remaining 5 mL supernatant, and the concentrated sample was plated on various growth media. The limit of detection for the identification of each pathogen was 250 CFU per hand. The identification of methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *Enterococcus* (VRE), multidrug resistant *Acinetobacter* sp, and *Clostridium difficile* are described previously.[8] Gram stains were performed on all isolates and coagulase tests were used to further confirm MRSA-positive samples.

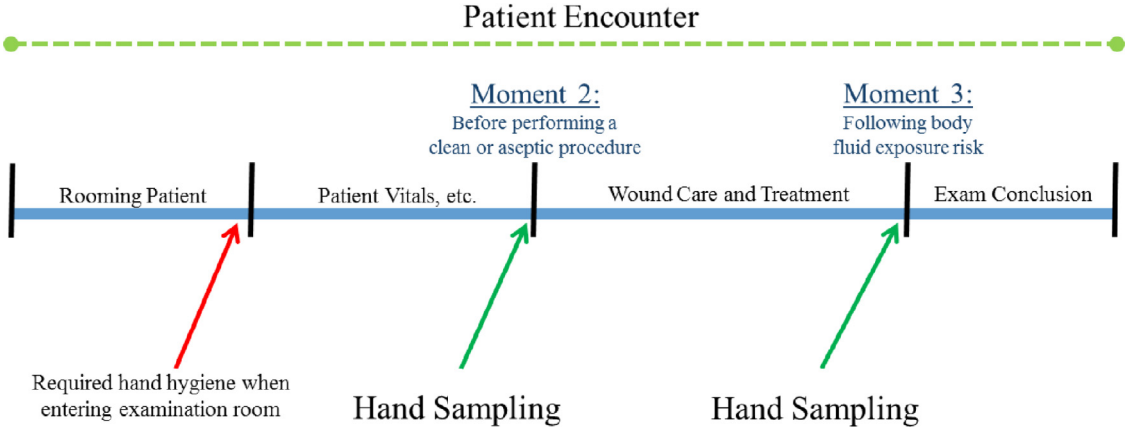

Fig 1. Patient encounter and hand sampling schematic.

Table 1
Breakdown of health care worker hand contamination during patient care encounters

Pathogen	Moment 2 events: Before clean or aseptic procedure (n = 46)	Moment 3 events: Following body fluid exposure risk (n = 46)	Patient care encounters (n = 46)
Methicillin-resistant *Staphylococcus aureus*	4.4 (2)	10.9 (5)	13.0 (6)
Vancomycin-resistant *Enterococcus*	2.2 (1)	0.0 (0)	2.2 (1)
Acinetobacter	0.0 (0)	2.2 (1)	2.2 (1)
Clostridium difficile	10.9 (5)	4.4 (2)	15.2 (7)
Any pathogen	17.4 (8)	17.4 (8)	28.3 (13)

NOTE. Values are presented as % (n).

Growth of any single organism was recorded as a positive for hand contamination.

Statistical analysis

The odds of hand contamination was assessed by a mixed effects logistic regression model with random effects for date crossed with facility, and HCW nested in facility. The random effects accounted for the repeated measures taken from each HCW, date, and facility. At moment 2, gloved and ungloved users were analyzed separately. At moment 3, there were no ungloved users. Thus, the effect of glove use is based solely on moment 2 data. Individual value plots, residual plots, and Hosmer and Lemeshow goodness-of-fit tests were used to assess the fit of the logistic regression model to the data. All analyses were performed using *lme4* in R (R Foundation for Statistical Computing, Vienna, Austria).[9] All statements of statistical significance are based on Wald tests at a significance level of 5%.

RESULTS

Prevalence of hand contamination

Seventeen HCWs from 4 facilities were sampled during 46 patient care encounters to determine the presence of health care-associated pathogens on their hands during critical moments of care. Hand hygiene with an alcohol-based handrub was performed by the HCW when entering the patient room to eliminate transient organisms present from contact with previous patients, environmental surfaces, or other sources. No confirmation of the effectiveness of hand hygiene during this step was performed considering the broad-spectrum antimicrobial activity of alcohol-based handrubs and the relatively high detection limit (250 CFU per hand). Hands were sampled before beginning wound treatment (ie, before clean/aseptic procedure [WHO moment 2]) and after wound treatment (ie, after body fluid exposure risk [WHO moment 3]). After the hand sampling procedure at moment 2, handwashing to remove the sampling solution also removed any remaining transient organisms. This prevented any cross-contamination into the sampling at moment 3.

HCWs acquired a health care-associated pathogen on their hands during 28.3% (13 out of 46) of patient care encounters (Table 1). When broken down by moments during care, 17.4% (8 out of 46) of hands sampled at moment 2 and 17.4% (8 out of 46) of hands sampled at moment 3 were positive for at least 1 pathogen. There were 3 patient care encounters (6.5%) where the HCW's hands were positive at both moment 2 and moment 3. However, only 1 of those cases involved the same organism. No HCWs were sequentially positive between patients for the same organism. This suggests HCWs in the study were contaminated by sources within the outpatient setting (eg, patients, environment, or staff) and not colonized with any of the targeted organisms. MRSA and *C difficile* were detected during 13.0% and 15.2% of patient care encounters, respectively, whereas VRE and *Acinetobacter* were each only detected in 2.2% of encounters. There was no access to patient medical records; therefore, correlation between the organisms identified from HCW hands and any known patient colonization or infection could not be made. Intrafacility hand contamination rates at moment 2 and moment 3 were similar and rates among facilities were also comparable.

Table 2
Incidence of hand contamination based on glove use

Time of care	Positive samples (n = 16)	
	Gloved	Ungloved
Moment 2: Before clean or aseptic procedure	40.0 (2/5)	14.6 (6/41)
Moment 3: Following body fluid exposure risk	17.4 (8/46)	NA (0/0)
Combined	19.6 (10/51)	14.6 (6/41)

NOTE. Values are presented as % (positive samples/total samples).
NA, not available.

Influence of glove use on hand contamination

Glove use during the patient encounter was self-reported by participants; however, the duration of glove use during care was not tracked. Hence, regardless of duration, wearing gloves at the moment of care was recorded as either positive or negative for glove use. Overall, hand contamination occurred in 19.6% of instances where HCWs wore gloves during care compared with 14.6% when HCWs did not wear gloves (Table 2).

During patient care that occurred at moment 2, HCWs wore gloves in 10.9% of occurrences (5 out of 46) (Table 2). Appropriateness of glove use at this stage of patient care was not assessed and hand hygiene immediately before donning gloves was not recorded. Hand contamination rates were 14.6% (6 out of 41) for ungloved hands and 40.0% (2 out of 5) for gloved hands. The contamination rate for ungloved hands was statistically significantly >0% ($P < .0005$) but the rate of contamination for gloved hands was not ($P = .657$). Lack of significance in the latter case may be due to the low sample size (n = 5) of glove users at moment 2. The odds of contamination was 3.9 times larger for gloved HCWs compared with ungloved HCWs, but this increase was not statistically significant ($P = .181$).

Gloves were worn during all wound care treatments (ie, the care given at moment 3) (Table 2). Hands sampled immediately after glove removal after wound treatment were found to be contaminated in 17.4% (8 out of 46) of occurrences, which was statistically significantly >0% ($P < .0005$). A comparison of the odds of contamination between glove users could not be ascertained because there were no ungloved HCWs during wound care treatment.

Influence of HCWs

Seventeen HCWs from 4 facilities were sampled during the study, which represented 85.0% of the eligible staff. On average, each patient encounter took 60 minutes for established patients or 90-120 minutes for new patients, and each HCW provided care to 6-10 patients per clinic day. Paired samples were taken during 9, 15, 10, and 12 patient encounters at facility A, B, C, and D, respectively. On average, each HCW was sampled during 1.8, 2.1, 2.5, and 1.1 patient encounters at facility A, B, C, and D, respectively, on each sampling day. When combined for all facilities, samples were taken during 1.7 patients encounters per HCW per clinic day, on average. This rate of sampling represented 17.0% of the high to 28.3% of the low daily patient load for each HCW.

Table 3
Analysis of hand contamination by health care workers

Hand contamination events	Percent of contaminated health care workers		
	Moment 2: Before clean or aseptic procedure	Moment 3: Following body fluid exposure risk	Patient care encounters
1	47.1 (8)	35.3 (6)	64.2 (11)
2	0.0 (0)	16.7 (2)	16.7 (2)

NOTE. Values are presented as % (n).

Eleven (64.2%) of 17 HCWs in the study were contaminated with a pathogen at least once during the combined 46 patient encounters, whereas 2 (16.7%) of 12 HCWs who gave care to at least 2 patients were contaminated during 2 of those patient encounters (Table 3). Eight HCWs (47.1%) were contaminated at least once at moment 2, whereas 6 HCWs (35.3%) were contaminated at least once at moment 3. The data indicate that the majority of HCWs' hands become contaminated during patient care and contamination is not associated with a subset of HCWs.

DISCUSSION

As health care transitions from hospital settings to outpatient settings the need for scientific evidence to support outpatient infection prevention practices increases. Although much has been published about hand hygiene and hand contamination in hospitals very little research has been conducted in outpatient care settings.[2,6] This study may be the first to investigate the presence of pathogens on HCWs' hands at WHO moments 2 and 3 for hand hygiene in an outpatient setting. These moments for hand hygiene typically occur behind privacy curtains or closed doors and even in hospital settings are less likely to be observed and recorded. In wound care settings, moments 2 and 3 occur during almost every patient encounter, providing an opportunity for transmission and/or acquisition of health care-associated pathogens by patients and HCWs.

In this study, HCWs' hands were contaminated during 28.3% of patient care encounters and when broken down by moments of care, 17.4% of the time before a clean or aseptic procedure (ie, before wound treatment) and 17.4% of the time after body fluid exposure risk (ie, after wound treatment). These contamination rates are similar to those reported during different moments of care in other outpatient settings, further supporting the importance of hand hygiene in these settings.[10-14] Hand contamination occurred as frequently after casual patient contact as it did after wound care, emphasizing that even brief contact can result in hand contamination. Studies, including 2 outpatient studies,[12,13,15-18] found hand contamination with organisms such as VRE, *S aureus*, and *C difficile* following casual or low-risk contact. Contamination rates in this study support the current WHO and CDC recommendations for hand hygiene before a clean or aseptic procedure and after body fluid exposure risk as ways to prevent the transmission of pathogens.

Glove use is explicitly linked with infection prevention and hand hygiene practices.[6,7,19] Wearing gloves when there is a potential for contact with blood, body fluids, mucous membranes, nonintact skin, or contaminated equipment is a basic tenet of standard precautions.[20] Furthermore, glove use is the strongest recommended infection control procedure to prevent the contamination of HCWs' hands.[21-24] In this study, gloves were not worn during 89.1% of contact before wound care. During wound care, when there was potential for exposure to blood, body fluids, and nonintact skin, gloves were universally worn. Studies have shown the rate of hand hygiene is lower when gloves are worn.[25,26] This study suggests that substituting glove use for hand hygiene can place both HCWs and patients at risk of colonization or infection with pathogenic organisms. Decontaminating hands after glove removal is a CDC recommendation (IB), and WHO guidelines clearly state that wearing gloves does not replace the need for hand hygiene.[6,7] Whether the contamination is related to the quality of the gloves or HCW practices in donning and doffing of gloves, knowledge and practices of infection prevention procedures (including donning and doffing of gloves) should be part of staff onboarding and also regularly reviewed. The recent Ebola virus disease outbreak in West Africa demonstrated the potential for self-contamination when doffing gloves and other protective equipment, and led to the practice of trained observers of HCWs when donning and doffing of protective equipment.[27]

Because of the contamination of HCW hands at moment 2 and moment 3 and the time pressure placed on HCWs, hand hygiene solutions need to be placed in convenient locations. Inconvenient placement of dispensers or sinks is cited as a reason for poor hand hygiene compliance by CDC and WHO.[2,6] Wound care clinics present a special challenge to place hand hygiene in convenient locations; therefore, manufacturers of hand hygiene products should consider options for nontraditional health care settings so that HCWs do not have to leave the patient zone to perform hand hygiene. As the delivery of health care shifts toward outpatient care settings, infection preventionists and HCWs in these settings should be consulted to advise a convenient location for hand hygiene dispensing products to accommodate their unique workflow patterns. One method to address the workflow and special hand hygiene requirements for outpatient settings is workflow mapping. Son et al[28] created workflow maps detailing the steps required to complete the 5 most common tasks, including indicating when hand hygiene was necessary. This process could be applied to the routine tasks of admitting patients to their room, helping patients onto the exam table, removal of wound dressing, application of new dressing, and helping the patient exit the room.

This study sought to understand the distribution of hand contamination among HCWs in outpatient care facilities. The majority of HCWs' hands (64.2%) became contaminated during patient care, demonstrating that contamination is not concentrated within a subset of HCWs. The distribution of sampling was not controlled in the study. The majority of HCWs were sampled during 1-2 patient encounters; however, several HCWs were sampled during 5-6 patient encounters. Increasing the sampling of those HCWs who were only sampled during 1 or 2 patient encounters may result in an increased percentage of HCWs with contaminated hands during patient care. Hand hygiene surveillance programs should be implemented to monitor compliance with hand hygiene guidelines due to the widespread hand contamination. In the outpatient setting, monitoring of hand hygiene compliance should include more than just room entry and room exit, but also within the patient zone. Observing hand hygiene behavior at WHO hand hygiene moments 2 and 3 is necessary for patient safety in a wound care setting.

LIMITATIONS

The results reported in this study may not be representative of all outpatient settings. Wound care facilities were chosen for this study because the care administered in this setting was likely to include both a clean or aseptic procedure and body fluid exposure risk. This setting may bias the results toward higher levels of hand contamination due to the type of care administered and the presence of pathogens in wounds. Wound care center patients may also be at higher risk for multidrug resistant organisms due to previous or current antimicrobial therapy, invasive procedures, and hospitalization. The sources of hand contamination could not be determined because environment contamination was not quantified

or characterized, baseline colonization of HCWs was not identified, and patient records were not accessed to determine infection status.

CONCLUSIONS

Outpatient care settings, especially wound care centers, present unique infection prevention challenges. The hand contamination reported at moment 2 and moment 3 provides a strong case for attention to hand hygiene and infection prevention practices in these settings to protect both patients and HCWs. The results of this study emphasize the need for attention to glove donning and doffing practices because glove use did not prevent contamination of the hands. The study also highlights the need for hand hygiene surveillance and hand hygiene solutions at the point of care so HCWs can clean their hands without leaving the patient zone.

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